

XVIII. *Observations on the Germination of the Filices.* By the
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SINCE the perfecting of a Natural Arrangement has become the grand object of scientific pursuit, it has been found necessary to enter more minutely than was required by an artificial system, into modifications of structure and function. Botanists have no longer rested satisfied with observing plants in their fully developed forms, but have also had recourse to several other periods in the existence of vegetable life, the observance of which gives much insight into the organisation of the individual. Of these there is none more important than germination, which is often the only means afforded for ascertaining the structure of the seed. This is the case with all the cryptogamic tribes, the seeds of which are generally so minute, that many of them must be brought together before they be distinctly visible. With such subjects dissection is hopeless, and a knowledge of their structure can only be derived, during their formation and evolution. The observations on this subject are as yet few, and those that have been made do not accord well with each other. Such at least is thought to be the case with the evolution of the Ferns. It appears, however, by a repetition of the experiments, and an uninterrupted series of observations on the evolution of the spore from first to last, that the discrepance of observation arises, not from any inaccuracy on the part of any observer, but by each looking at periods of evolution different from the other ; by do-

ing which, each saw forms apparently irreconcilable, and by a law of our nature, which requires us to believe the testimony of our own senses in preference to that of another, late observers have been led to attach doubts as to the accuracy of preceding observations, which nothing but a different result, obtained by the same process, could vindicate.

It has been the fate of LINDSAY, the first observer of importance, according to the opinion of late and far more enlightened naturalists, to see "several whimsical shapes *," which succeeding observers have not been able to recognise †. His observations ‡ were made at Jamaica some time previous to the year 1789, and the engravings were executed in England, where he had no opportunity of superintending, so as to correct errors. Notwithstanding, the figures are tolerably accurate, and certainly entitle the author to more merit than has of late been awarded to him. They commence with the sporule soon after germination, and he gives several representations of the plantule in successive stages, as seen by a high magnifier. These correspond to the first seven figures in the accompanying drawing; and, except that he has represented the radicles in all of them as proceeding from the sporule alone,—an error, it must be confessed, which of itself shews that he did not understand the peculiarity of the evolution,—they are not very unlike what the author has observed. He then permits some weeks to pass without observations, until the little plants begin to appear to the eye as small heart-shaped scales. His observations then correspond to the accompanying Figures 10, 11, 12, 13, 14, Plate XI.; they are represented of the natural size, and are tolerably just. The

* Sup. to Encyc. Brit. Art. Anat. Veg.

† Edin. Encyc. Art. Filices.

‡ Lin. Trans. vol. ii. p. 95.

greatest fault in his observations is, that he neglected to observe a most interesting process in the evolution, and by proceeding *per saltum* from the period at which a high magnifier was necessary to render his early forms visible, to the time when these appeared to the eye as small scales, he has represented forms nowise connected with each other, which has led late observers to doubt their accuracy. Of these, the most distinguished is the author of the article Filices in the Edinburgh Encyclopædia, published in 1815. The experiments which he there describes commence soon after what he terms the "seed-lobes" become visible to the naked eye. Of course they correspond to the second sets of LINDSAY's observations, and, though much more perfect, are on a general view pretty similar. He has remarked the temporary radicles, the true root, and the elevation around the opening formed by the emission of the true frond, on all of which LINDSAY is silent. Besides these, several others have noticed ferns in the act of germinating. EHRHART seems to have observed some of the earlier forms of LINDSAY. SPRENGEL saw a single species in a state of spontaneous germination, in its farthest advanced states, forms in which young ferns are to be seen in every shady moist crevice, or other place where ferns grow. MIRBEL has also observed some of the later stages, differing in some unimportant particulars, in the form of what have been named the Seed-lobes.

Notwithstanding, however, that observers have been so numerous, it does not appear that the true mode of the evolution has as yet been understood. LINDSAY makes no attempt to reconcile his early with his later forms; while the author of the article Filices, though he made experiments on various genera, could never observe the first forms of LINDSAY. These circumstances are easily explained, however, if the appearances presented during the evolution of *Polypodium vulgare* be similar to

those of the other individuals of this natural family ; and this we may safely conclude of all those at least having prostrate stems. The accompanying figures are representations of what the author has observed in that species. In the explanation, no dates are given, as the progress of germination depends entirely on the age of the sporule, the supply of moisture, temperature, &c. which are the measures of the progress of vegetation rather than of equal spaces of time.

After seeing the observations in the Edinburgh Encyclopædia, it occurred to me that the seed of the Filices must consist chiefly of two cotyledons folded together, which, by the absorption of moisture, and the germinating power, resolved themselves into the forms represented by the author of that article ; an idea in which I was confirmed by observing the sporule of *Polypodium vulgare*, which appeared under a high magnifier curiously folded together like the surface of a brain. Whatever the surface of a sporule may be, however, the idea that it consists of two folded cotyledons is altogether erroneous. The opinion of GÆRTNER, that the testa of the seed is in them as well as in the Musci and Fuci, totally occupied by what he terms *vitellus*, seems much nearer the truth. The evolution of the Musci, indeed, has so many points in common with that of the Filices, as to indicate a similar structure of the sporule. HEDWIG, and, after him, Mr DRUMMOND of Cork *, when observing the young shoot from the seed of *Funaria hygrometrica*, saw that it had ruptured the integument, which, until more extensive experiments be made, may be considered as an epidermis. But whether this coat be, as in the higher vegetables, an integument of a different structure from the enclosed parts, and existing previously to the action of atmospherical causes, or whether it be a natural change

* LIN. Trans. Vol. xiii. Part 1.

produced by their action upon the uniform substance of the sporule, after the soft matter in the theca has resolved itself into little concretions, conducing powerfully to the preservation or the vital principle in the interior, and similar to a change observed to take place on the surface of *Vorticella rotatoria*, and other aquatic animalcula, when, by some accident, they have been exposed to the action of the air, and by which the principle of life has been wrapt up for several years, is not determined. The sporules of these two acotyledonous tribes seem to be small concretions of matter produced in the reproductive organs of most species, possessed of the vital principle of those species without the action of sexual parts, and of the power of giving rise to forms of germination peculiar to the family to which they belong; which intermediate forms, in their turn, and after the action of the sporule has ceased, have a similar power of evolving the mature forms of the species. The irregularity in size, form, and surface, observable even from the same theca, seems to countenance this idea of the simplicity of the sporule. In *Polypodium vulgare* they are comparatively large; they vary in surface, from nearly echinated to nearly smooth, and in form from globose to reniform. In *Pteris crispa* they are generally equilateral triangular pyramids, more or less perfectly formed; but they vary from having plane sides and sharp angles to globose.

Still, however, though this simplicity of structure were granted to the sporule of the Filices, it does not follow that this magnificent family must be ranked with the Acotyledones. After leaving the Dicotyledones, we do not observe the same uniformity in the structure of the embryo. BROWN, our illustrious countryman, has shewn *, that certain Aroideæ produce seeds which have an appearance and economy much more nearly resembling the tuber of a root; for instead of being distinguishable into a

* LIN. Trans. vol. xii.

cotyledon, a plumule and radicle, and of germinating in a determinate manner, and from a single point ; they are composed of a mass, whose internal structure is uniform, and on the surface of which frequently more than one germinating point are visible. And, there is reason to believe, that there are other families in this class, the structure of whose seeds is equally anomalous.

The author of the article alluded to was led to conclude, from his observations, that the seed-lobes of ferns possess not only an analogy with, but partake of the essential properties of cotyledons, as far as these have been accurately defined ; and though he mentions some respects in which the germination of ferns is peculiar to this family, he gives particularly three in which it agrees with *other* dicotyledonous plants. The first is, that the seed-lobes constitute the body of the minute seed. Should the general mode of germinating throughout the family be uniform, of which, as that writer remarks, there can be little doubt, this cannot be the case ; for in every instance where the sporule has been seen, and as long as it has been observed, it remained of nearly its original form and size, which could not have happened, had not what have been considered as seed-lobes been solely the result of germination. The other two are, that these seed-lobes nourish the other organs of the embryo, which they include within their substance ; and that these organs germinate from a tuber situate in the centre of the lobes. They certainly do nourish the true bud, after they have disposed of the nutritious matter derived from the radicles for their own aggrandisement, until the law of their life does not permit them to increase in size, but not till then do they form a bud ; and their action in doing so, is not by yielding any albuminous matter contained in their substance, as in true cotyledons, for they are thin cellular membranes, and their function seems to be to convert the fluids received from the numerous radicles on their under surface, into the forms of the species.

Were we to seek for analogies to these hepaticoidal forms of ferns, in more highly organised bodies, we do not know where to find them beyond the limits of this family. But there are several circumstances which might lead us to view them as representatives of the prostrate stem. They originate from the sporule, a minute tuber; they soon after emit radicles, which penetrate the soil, and contribute to their increase, and, when arrived at sufficient strength, they form a bud. And perhaps it may be found, by future observations, that the elongation of the hepaticoidal form, and the successive emission of radicles farther up, are confined to those species having prostrate stems.

It is not among the Dicotyledones that the Filices lay any claims to rank. Some most eminent botanists, however, have classed them among the Monocotyledones; a place assigned them chiefly from the structure of the stem, in which the occurrence of vascular fasciculi, and certain modes of growth, indicate many points common to them and to species decidedly monocotyledonous. But the detection of vessels in the stems of Ferns, and in other nearly related tribes, may have arisen from the circumstance, that they exist there in a state easily detected, while the minuteness of some other families very much limits the success of dissection. In this question habit gives little aid; for the gigantic arborescent species seem to approach as nearly to the magnificent Palms on the one hand, as the humble *Trichomanes* and *Hymenophylla* do to the Mosses on the other. But while the whole reproductive system is truly cryptogamic, and the object of the botanist to confine to one of three classes the almost infinite modifications of structure in the vegetating world, it seems preferable, at least, until the structure of several other cryptogamic tribes be investigated, to attach that importance to the fructification which has usually been given it, and to place them, where they have generally stood, among the Acotyledones;

although, if authority were sufficient to satisfy the doubts of all, their station should be among the Monocotyledones, having been placed there by the two greatest botanists of the age, BROWN and DE CANDOLLE.

EXPLANATION OF PLATE XI.

- Fig. 1. A sporule of *Polypodium vulgare* begun to germinate. The frondose portion is somewhat advanced before any radicles are emitted. Figs. 2, 3, 4, 5, different stages of progress. Fig. 6., at this stage the cellular structure becomes distinct, and radicles are emitted from the lower portion of the frond. Figs. 7, 8., the fronds now become emarginate, and curiously apiculate. The radicles are emitted from the margin and under surface. Those from the sporule and lowest part of the frond begin to shrink, along with that portion of the frond, as in Fig. 9., until, as in Fig. 10., the sporule is separated.
- Fig. 11. The true frond beginning to shoot out from the centre of the hepaticæ-like form (copied from the Edinburgh Encyclopædia, Art. Filices).
- Fig. 12. Plantule of *Aspidium Filix femina*, (copied from SPRENGEL's Introduction to the Study of Cryptogamic Plants).
- Fig. 13. Plantule of *Polypodium lycopodioides* (copied from LINDSAY's Observations, &c. LIN. Trans. vol. ii.).
- Fig. 14. *Aspidium aculeatum* (LIGHTF.) in a state in which they are easily found growing spontaneously.

The first ten figures are magnified.

